

Issued January 17, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

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REPORT

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OF

# THE ENTOMOLOGIST

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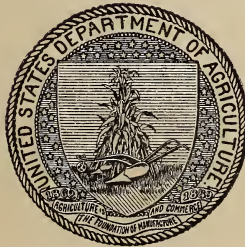
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BY

L. O. HOWARD.

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[FROM ANNUAL REPORTS, DEPARTMENT OF AGRICULTURE.]



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1908.



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# CONTENTS.

	Page.
Work of the year-----	5
Work on the Mexican cotton boll weevil and other insects affecting cotton -----	6
Work on the gipsy moth and brown-tail moth-----	11
Importations of useful insects-----	13
Exportations of useful insects-----	17
Investigations of insects damaging forests-----	18
Investigations of insects damaging deciduous fruit trees-----	20
Field-crop insect investigations-----	24
Work on insects injurious to vegetable crops-----	27
White fly investigations-----	28
Investigations of insects in their direct relation to the health of man and domestic animals -----	30
Work on scale insects -----	31
Experimental work with insecticides-----	31
Investigations of insects affecting tobacco-----	32
Inspection work-----	33
Work in bee culture -----	34
Work in silk culture -----	37
Miscellaneous investigations, the exhibit at the Jamestown Exposi- tion, and other work -----	39
Proposed work for the fiscal year 1908-----	40
Suggestions as to work recommended for the fiscal year ending June 30, 1909, for use in preparing estimates-----	44



## REPORT OF THE ENTOMOLOGIST.

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF ENTOMOLOGY,  
*Washington, D. C., August 9, 1907.*

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1907, dividing it, in accordance with your instructions, into the following headings:

(1) A summary of the important operations carried on during the fiscal year 1907.

(2) An outline of the plans proposed for work for the fiscal year 1908 under appropriations already made for that year.

(3) Suggestions as to work recommended for the fiscal year ending June 30, 1909, for use in preparing estimates.

Respectfully,

L. O. HOWARD,  
*Entomologist and Chief of Bureau.*

HON. JAMES WILSON, *Secretary.*

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### WORK OF THE YEAR.

The work of the Bureau during the year beginning July 1, 1906, and ending June 30, 1907, may be classified as follows:

(1) Work on the Mexican cotton boll weevil and other insects affecting cotton.

(2) Work on the gipsy moth and brown-tail moth.

(3) Importations of useful insects.

(4) Exportations of useful insects.

(5) Investigations of insects damaging forests.

(6) Investigations of insects damaging deciduous fruit trees.

(7) Field-crop insect investigations.

(8) Work on insects injurious to vegetable crops.

(9) White-fly investigations.

(10) Investigations of insects in their direct relation to the health of man and domestic animals.

(11) Work on scale insects.

(12) Work on insects injurious to stored products.

(13) Experimental work with insecticides.

(14) Investigations of insects affecting tobacco.

(15) Inspection work.

- (16) Work in bee culture.
- (17) Work in silk culture.
- (18) Miscellaneous investigations, the exhibit at the Jamestown Exposition, and other work.

WORK ON THE MEXICAN COTTON BOLL WEEVIL AND OTHER INSECTS  
AFFECTING COTTON.

The work of the Bureau of Entomology on the cotton boll weevil was continued during the fiscal year 1907 under Mr. W. D. Hunter, to some extent along the lines of previous investigations, though new features that have an important bearing on practical control were given attention. In the case of a pest that causes an annual loss of about \$25,000,000, falling upon a single industry restricted by climatic conditions to less than one-fourth of the area of the United States, it is evident that the very fullest knowledge of its life history and habits must be obtained and disseminated. Naturally, any means of control must be based upon this information. Partially successful means of control or means of use in restricted regions or under special conditions can not be considered as satisfactory. Continued efforts must be made until the best possible means of control are devised and tested in the field. The problem caused by the boll weevil is made more difficult and more work is required by the fact that the insect is adapting itself to new conditions and changing its habits in ways that interfere seriously with the present means of control. The work conducted by the Bureau of Entomology has been classified under the following heads.

EXPERIMENTAL FARMS.

As in the preceding year, the Bureau has conducted a number of large-scale field experiments. The experimental farms were of from 10 to 65 acres in extent and located in various regions where the weevil problem assumes local aspects. They were primarily of an experimental character, but incidentally of great value as practical demonstrations of the success that may be attained by following the recommendations that have been made by the Bureau. Careful studies and records were made and valuable practical information obtained. The season was abnormal and the necessity for the continuance of such work through a series of years in order to obtain exact information was again demonstrated. The experimental farms were located in the following counties in Texas: Robertson, Navarro, Travis, Dallas, Henderson, Karnes, Hunt, Bowie, Denton, Kerr, Wood, and Llano; and in the parishes of De Soto and Vernon, in Louisiana. Similar work was also conducted near Ardmore, in Indian Territory. The total area covered by these experiments was 378.5 acres. The work was arranged, as has been the case in the past, under a contract which gave the Department practically absolute control of all details. The total cost of this work to the Department was about \$800.

In addition to the work under contracts, nearly 500 acres were utilized under a merely cooperative arrangement with farmers in many localities, without any expense whatever to the Department.

## SPECIAL FIELD EXPERIMENTS.

In the last annual report attention was called to the necessity for a large-scale experiment in the fall destruction of cotton plants. This practice has been tested on a small scale in many localities and its efficiency has been demonstrated. Nevertheless, there are practical difficulties in the way of a general following of the practice by farmers, who have been slow to take it up. It was therefore decided to conduct a larger demonstration than had been possible in the past. To do so a locality was found in Calhoun and Jackson counties, in Texas, where 25 or more farmers had an aggregate of 410 acres of cotton. This locality was isolated completely from other cotton. On one side was the Gulf of Mexico, on another a broad arm of the Gulf, and on the remaining sides large stretches of swamp lands. The nearest cotton was about 10 miles distant. An agent of the Bureau of Entomology succeeded in inducing all the farmers in this locality to destroy the cotton stalks early in October. Their work was done under contract, which gave the Department authority to see that the work was done quickly and well. During the first ten days in October all of the cotton was uprooted and burned. Examinations that have been made this season show the very great importance of the work done during the preceding fall. Up to the present time (July, 1907) there has been virtually no weevil infestation in the area where the cotton was destroyed and where the same crop was planted this season under the usual conditions. In fact, for some time it appeared that the weevils had been absolutely exterminated. However, in June it was found that a very few of the insects had come from hibernating quarters in a hedge near one of the cotton fields. This resulted in an extremely slight local infestation. A large area of cotton growing across the bay, at a distance of about 15 miles, has been used as a check on the experiment. In the case of this check, the cotton stalks were not destroyed until December and January, which is the usual practice in that region. The plants were uprooted and destroyed only as an incidental step in the preparation of the land for planting. On this area in June an infestation of at least 50 per cent of the fruit on the plants was found. The prospects of making a crop are consequently very small, while on the experimental area it is scarcely possible that any conditions can now interfere with making a very large crop. The early destruction of the plants practically eliminated the boll weevil as a factor in cotton production for this season. In addition to the practical demonstration just referred to, a large amount of data was obtained from practical cotton growers in many localities who have practiced the fall destruction of plants. All of this information will be embodied in a special report that will be issued during the present season.

It has frequently been urged that it might be possible to control the boll weevil more effectively by late planting of cotton than by the early planting which has been recommended by the Bureau of Entomology, and which has come to be generally practiced. It has been supposed that the lengthening of the hibernation period by deferred planting rather than by the fall destruction of plants would be as effective as that process and much easier to place in operation on the average farm. In order to test this matter fully a number of

special field experiments was arranged. These experiments were located at four places in as many agricultural provinces in Texas and at one place in Louisiana. The latter work was done in cooperation with the Louisiana crop-pest commission. The results of these experiments have been referred to in an article in the Yearbook of the Department for 1906. In brief, the fallacy of late planting was proven beyond any possible doubt. In not one of the four cases in Texas was any appreciable amount of cotton produced. The plants grew well, but the boll weevil appeared in such numbers as to destroy practically all of the crop. The fields used were extremely isolated, and there could have been no invasion of weevils from outside. It is therefore certain that the insects may survive long enough to attack cotton planted as late as the middle of June and destroy it. This work is a complete refutation of the theory that has been proposed, and the publication of the results will undoubtedly prevent the useless expenditure of money by many farmers.

#### WORK ON THE CONTROL OF THE WEEVIL DURING THE HIBERNATION SEASON.

Many details connected with the proper procedure in the fall destruction of the cotton plants can only be determined by special field experimentation. One of these points is the approximate time in the fall when the work should be done. In order to obtain the necessary information the Bureau of Entomology conducted three large experiments at Victoria, Calvert, and Dallas, Tex. At each of these places large cages (20 by 50 feet) were erected over cotton growing in the fields. Each of these cages was divided into ten sections. Early in October the plants were removed from one of the sections at each of the places mentioned, while the weevils were allowed to remain. In order to make the results more satisfactory numbers of weevils collected in the field were placed in these sections immediately after the removal of the plants. In all, over 70,000 weevils were utilized. At regular intervals subsequent to the removal of the plants from the first cage, other sections were treated likewise. In the cage experiments, of course, accurate notes have been made regarding the number of weevils that have survived the winter. In this way it will be possible to determine exactly what benefit a farmer may obtain in southern, central, or northern Texas by the destruction of the cotton plants at various dates through the fall and winter. This work will give the farmers exact information as to what they may accomplish by the destruction of the plants at different times in the fall and will probably emphasize the supreme importance of the earliest possible destruction.

As has been the case in the past, a considerable fund was set aside by the Bureau of Entomology as a reserve to be used in the eradication of isolated colonies that may be expected at any time. With the increase in infested area and the proportionate increase in the amount of farm commodities shipped from it to regions where the boll weevil does not occur, the danger of the occurrence of isolated colonies has recently increased enormously. In one instance an isolated outbreak was completely eradicated by the Louisiana State authorities, and there is no reason why similar results might not be obtained in case, for instance, a colony should be found in South Carolina. If it were discovered in time energetic work would save hundreds of thousands of dollars to the State concerned.

## WORK DIRECTED TOWARD THE PRACTICAL UTILIZATION OF THE PARASITES AND PREDACEOUS ENEMIES OF THE BOLL WEEVIL.

By all means the best method of controlling injurious insects is the encouragement of the natural checks provided for them—that is, parasites and predaceous enemies. Most conspicuous examples of effective entomological work have involved the use of this method. In the case of the boll weevil there are many difficulties. One of these is that the insect works within the tissues of the plant in all stages, except one, so that it is better protected from its enemies than many others. Another obstacle lies in the fact that the boll weevil is a new insect in the United States, having left behind the parasites that control it in its original home, and until very recently there has not been sufficient time for the native parasitic agencies to come into operation. An important line of work undertaken in the fiscal year 1907 was a careful study of this matter. It was first necessary to examine many thousands of squares and bolls from various localities in the infested area to determine what different parasites and predaceous insects were present in different quarters. It was also necessary, when parasites were found, to ascertain the source from which they came. This involved much careful investigation of insects related to the boll weevil infesting various plants growing in and about cotton fields. It was found that fifteen different insects which attack the boll weevil in its immature stages are now at work to a greater or lesser extent in the infested territory. The number is undoubtedly increasing, and will continue to do so as the boll weevil invades regions where parasites of other weevils are present. That the matter is not one of small importance at present is indicated by the fact that in a field near Waco, Tex., it was found that fully 40 per cent of the weevils had been killed by the combined work of several species of parasites.

Practical results of the work on parasites are already in sight. Among them may be mentioned the feasibility of the collection and propagation of parasites and their distribution in regions where the same species are either absent or present in but small numbers. In an experiment performed in the summer of 1906 a number of parasites were taken from Waco, Tex., and liberated in a cotton field near Dallas, Tex. Apparently by this means the mortality rate due to parasites was raised in a few weeks by about 9 per cent. Another practical point that has been brought out is that, by the elimination of weevils related to the boll weevil by the destruction of their food plants in or about cotton fields, the farmer may force the parasites to transfer their attention to the boll weevil. It was, of course, only after very careful studies of the weevils of various species occurring about cotton fields that the information necessary for this procedure could be obtained. Now, however, as a result of the work that has been done, it may be pointed out what plants are infested by weevils the parasites of which may attack the boll weevil and the exact time when these plants should be cut down. Other practical points and field tests remain to be undertaken.

The studies of the parasites of the boll weevil have brought to light many matters that have a general bearing on the control of injurious insects everywhere. The results obtained up to the present time have been submitted for publication in a bulletin which will shortly appear.

In addition to the parasites referred to in the preceding paragraphs, at least one very important predaceous enemy of the boll weevil has been found, namely, the native fire ant, *Solenopsis geminata*. This insect is not to be confused with the Guatemalan ant. It occurs throughout the cotton belt and has been found to be a very important factor in controlling the boll weevil in its original home in Central America. In this country it is rapidly acquiring a habit of feeding upon the boll weevil. In order to determine exactly what work is being done by this ant and the conditions most favorable for it, large numbers of squares were examined from cotton fields in various parts of Texas. The importance of the ant's work was clearly shown as a result of these examinations. At Beeville, Tex., for instance, in August, 1906, out of 874 weevil stages found, 684 had been destroyed by ants. The studies conducted showed the comparative effectiveness of control by the ant in various localities in Texas and Louisiana, and also the special conditions in any one locality which favored the work of the ant. Information of this kind in many cases can be made of practical use in the location and management of cotton fields. The whole matter will receive careful attention in a publication of the Department that is about to be issued.

#### MISCELLANEOUS WORK.

In addition to the principal lines of investigation referred to, considerable work has been necessary to determine the status of the boll weevil at different times. There is a constant and legitimate demand for information as to the probable damage by the pest, and reasonably safe predictions may be made from the field examinations early in the season, provided they can be extended over sufficient territory. During the fiscal year 1907 several general examinations were made. These involved the work of eight or ten entomologists for about ten days' time. The first examination was made in June, and the results which were published indicated clearly that the damage to be expected from the boll weevil during the year would be much less than normal. This prediction was verified later by the very large crops produced in the infested territory.

There is also great demand for information regarding the additional territory that becomes infested by the boll weevil from time to time. To supply this information men were placed in the field to determine the exact extent of the dispersion of the insect, and the results were expeditiously published in the form of maps.

As in preceding years, a number of preparations designed to destroy the boll weevil were tested at the laboratory at Dallas. Many mechanical devices were also investigated. This line of work is absolutely necessary to refute the claims of overenthusiastic persons and thereby to prevent the useless expenditure of money by farmers. Many addresses were delivered at meetings of farmers, and many special articles were written for agricultural papers on matters of local or general concern. As usual, a large amount of information was disseminated through correspondence.

The work in cooperation with State experiment stations was continued. One man was detailed to the Texas experiment station and three were detailed to the crop-pest commission, which is virtually a part of the experiment station organized in Louisiana.

## WORK ON THE COTTON BOLLWORM AND OTHER COTTON INSECTS.

The bill appropriating for the expenses of the Department of Agriculture for the fiscal year 1907, in its emergency appropriations, did not contain the same specific mention of the cotton bollworm as did that of the previous year, and in fact the work of the previous year had practically completed the investigation. Seven demonstration experiments, however, were carried on, based upon the information gained by the work of the previous years—five in Texas and two in Louisiana. The results of the entire work have been carefully summed up in Farmers' Bulletin No. 290, and it seems obvious that by following carefully the recommendations given in that bulletin cotton planters can reasonably expect to escape serious damage by this destructive insect.

The incidental work on other cotton insects has also been carried on in cooperation with the Texas State Agricultural Experiment Station. An assistant has been stationed at the State college, as in the previous year, carrying on certain experimental work with the cotton insects of minor importance, and particularly with the cotton aphid, as indicated in the last report.

## WORK ON THE GIPSY MOTH AND BROWN-TAIL MOTH.

As indicated in the last annual report, under the head of "Proposed work for the fiscal year 1907," headquarters for this work were established in Boston; Mr. D. M. Rogers was placed in charge of the work, a large force of laborers was engaged, and energetic work was begun immediately when the appropriation became available. Under the terms of the appropriation, the efforts of the Bureau have been directed toward preventing the further spread of the gipsy moth and the brown-tail moth. As previously shown, there is a radical difference in the possibilities of effective work to prevent the spread of these two insects. The brown-tail moth is a ready flier, and at the time the work began had already covered a great extent of territory, reaching from Amherst, Mass., to a point high up on the Maine coast. At the time of its annual flight it is carried by prevailing winds, often for hundreds of miles from its place of birth, and an effort to prevent its spread seems almost hopeless except by the active cooperation of every property holder in the infested territory. The campaign against this insect has therefore been begun as an educational campaign, and the importance of local effort has been shown as forcibly as possible. An illustrated farmers' bulletin has been published and distributed widely throughout the infested territory, and State and local officials have been urged to do everything in their power to induce the destruction of the winter nests. The States of Maine, Connecticut, Rhode Island, and New Hampshire, in addition to the State of Massachusetts, have passed laws based upon the Massachusetts law and have made appropriations for State work. While these appropriation laws include the gipsy moth with the brown-tail moth, the brown-tail moth is receiving from the outlying States perhaps more attention than the gipsy moth.

The conditions are quite different with the gipsy moth. The female can not fly, and the species is distributed by the caterpillars, which, spinning down from trees overhanging the roadsides, are

carried long distances by automobiles, carriages, trolley cars, and other vehicles, and shorter distances by pedestrians. The species was known to occur, at the time when work was begun, in a rather definitely restricted region, including the eastern portion of Massachusetts, one locality in Rhode Island, one in Connecticut, and several in the southeastern portion of New Hampshire. Within this territory the caterpillars were to be found in the forest land, in public parks, in orchards, and upon the street trees of cities and roadside trees in the country. Two methods of work were obvious—one to work upon the outer border of the infested territory and gradually retract the line of spread toward the center. This method, however, was deemed inadvisable for the reason that the principal spread is surely from the interior to new points beyond the line by means of vehicles, as just indicated. Therefore the second method was adopted, which consists in working along the thoroughfares leading from the most seriously infested localities, and this work was prosecuted in the summer time and autumn months of 1906. A strip of about 100 feet wide on each side of the road was cleared up; all underbrush was cut out; poor trees were removed, and the remaining ones were pruned; all debris was burned. Such work has been done during the year in Malden, Melrose, Saugus, Wakefield, Lynnfield, Peabody, Woburn, Lexington, Burlington, Waltham, and Belmont—in all about 65 miles of road, 100 feet on each side.

In the fall of 1906, after the gipsy moth had deposited its eggs, selected men were taken from the force and sent over the 100-foot strips, treating all egg clusters with creosote oil. This work was continued until May, 1907, when the eggs began to hatch. During the latter part of April and the first part of May the trunks of the trees in all of these strips were banded with sticky bands to prevent the ascent of caterpillars which might have hatched from broken egg clusters or which might come from the territory back of the 100-foot strips. The same trees were also banded with strips of burlap above the sticky bands, so that such caterpillars as might hatch in the trees above the bands could be caught in the burlap hiding places.

About the first of June spraying operations were begun. Four spraying machines operated by gasoline engines were used, and the spray consisted of arsenate of lead in the proportion of 10 pounds of poison to 100 gallons of water. This spraying continued until the close of the fiscal year and later.

The work was done entirely in the State of Massachusetts, since outlying colonies have all been shown to have originated from the section included in this work. But in addition to the Massachusetts work, an arrangement was made with the authorities of Rhode Island whereby the force of men employed by that State, on the lapsing of the Rhode Island appropriations, was transferred to the Bureau on July 23, 1906. These men were kept at work until May 15, 1907, and on the passage of the Rhode Island appropriation bill were retransferred to State authority on May 16. This force examined every tree and most of the shrubbery and thousands of buildings and fences in the city of Providence, destroyed all the gipsy-moth egg clusters that could be found, treated all trees having cavities which could be used as hiding places for the caterpillars, located the egg clusters, and cleaned up all around the infested places in Cranston, Johnston, North Providence, East Providence, Pawtucket, and

Barrington. The work was so well done that it is difficult at this date of writing to find a gipsy-moth caterpillar in the State. At the beginning of the work the gipsy moth was thought to be confined to the city of Providence, but as it progressed it was found in the six additional localities above mentioned. Some scouting was done in northeastern and southern Rhode Island, but no gipsy moths were found; the brown-tail moth, however, was discovered in Woonsocket, Cumberland, Central Falls, and Pawtucket.

A small gang of men was sent to Connecticut March 20, 1907, to scout in the territory about the gipsy-moth colony at Stonington. A thorough examination was made of this town and some scouting was done in the towns of Groton and North Stonington, but no insects were found except in the immediate vicinity of the territory already known to be infested, which is about 1 square mile in area and is being cared for by the State.

Early in the fall of 1906 scouting operations were begun in New Hampshire, at the southeastern corner of the State, where the gipsy moth had been discovered the previous year. This scouting was continued until June 30, 1907, and the gipsy moth was discovered in 35 of the 77 towns that were inspected.

In November, 1906, scouting was begun in Maine, and was continued until May 25, 1907. Thirty-five cities and towns were examined, and the gipsy moth was discovered in eight. With the exception of a single egg cluster found at the Soldiers' Home at Togus, Chelsea, Me., the known infestation is confined to the extreme southwestern portions of the State, in the towns of Kennebunkport, Kennebunk, Wells, York, Kittery, Eliot, and South Berwick.

As above stated, all of the New England States in which the gipsy moth is known to occur have appropriated funds and have enacted laws directed toward the gipsy moth and the brown-tail moth during the past winter. Maine appropriated \$30,000 for 1907 and \$30,000 for 1908; New Hampshire appropriated \$25,000 for the two years 1907 and 1908; Rhode Island and Connecticut each appropriated \$10,000, or so much thereof as may be necessary.

The laws of the infested States, if enforced, will probably be effective in keeping the pest in check in the residential sections, but the forest lands will suffer greatly unless sufficient appropriations can be secured to care for them, or unless the parasites imported from Europe, which will be mentioned in a later section of this report, multiply sufficiently to reduce the insects to a minimum in such sections.

The work that has been done under the auspices of the Bureau has been careful and thoroughly effective. The experienced superintendent of the Massachusetts State work, Mr. Kirkland, states that he has never seen more careful and thorough work done.

#### IMPORTATIONS OF USEFUL INSECTS.

The work of the Bureau in importing useful insects has been devoted almost entirely to continuing the importation of parasites of the gipsy moth and the brown-tail moth. During the early part of the fiscal year packages containing parasitized caterpillars of both species continued to be received from European agents. These

were cared for, as stated in the last report, in the laboratory at North Saugus, Mass. Parasites of a large number of species were reared; some were liberated in the open, and others were studied in confinement in larger or smaller breeding cages. Following the experience of the previous winter, when good results were obtained by the importation of large numbers of the hibernating nests of the brown-tail moth, from which in the early summer were reared parasites belonging to species which infest both the gipsy moth and the brown-tail moth, during the winter of 1906-7 more than 111,000 hibernating nests of the brown-tail moth were brought over from different portions of the European range of this species. These were placed in specially constructed cages, and from them large numbers of parasites were reared. They issued mainly during the month of May. As it happened, the month of May in New England, as well as in other parts of the United States, was phenomenally cold and wet. As a result of this unlooked for condition very many of the parasites refused to leave the nests until they were so weakened as to be unable to survive the close confinement and careful scrutiny to which they were necessarily subjected in order to eliminate the danger of introducing secondary parasites. As a result a smaller number of this group of parasites (*Pteromalus*) was colonized than in the summer of 1906, but 40,000 specimens were put out in several localities, the principal colonies consisting, respectively, of 13,000, 11,000, and 7,000 individuals.

In this important work with the introduced hibernating nests of the brown-tail moth it was early found most difficult to preserve the health of the laboratory assistants. The irritating and poisonous hairs of the brown-tail moth larvæ, of which the nests are full, soon penetrated the skin of the assistants handling them, entered their eyes and their throats, and the atmosphere of the laboratory became almost filled with them. It was necessary that the laboratory rooms should be kept thoroughly closed; double windows and screens were used, and the doors to the rooms were darkened in order that a possible secondary parasite becoming accidentally liberated should have no chance of escape. This made the rooms very warm and increased the irritating effect of the larval hairs. Some of the assistants employed could not stand the work and resigned. One of the best and most experienced was induced to continue the present year only upon promise that he should be relieved from this especial class of work. Spectacles, gloves, masks, and even headpieces were invented to avoid this difficulty, but these, while greatly increasing the suffering from heat, were not entirely effective. The most serious result of this trouble was the breaking down in health of Mr. E. S. G. Titus, in charge of the laboratory, who was obliged to resign in May, 1907, on his physician's advice, in order to save his life. The difficulty in Mr. Titus's case was the intense irritation to his lungs from the entrance of the barbed hairs. Mr. W. F. Fiske was sent from Washington to replace him, and has since had charge of the laboratory. New methods of handling the brown-tail nests have been invented, and it is hoped that this difficulty will be measurably obviated in the future.

The Chief of the Bureau visited Europe again during May and June, 1907, engaging new voluntary assistants among European entomologists and establishing a very effective corps of observers in Russia, a country which has not before been called upon. At Kief,

Kishenef (Bessarabia), and Simferopol (Crimea) stations were established and much good and new material has been sent in. At Kief a large experimental orchard was engaged for scientific observations and for the purpose of collecting and caring for parasitized larvæ in large numbers. New collections were made in Germany, and an experimental station was established near Rennes, in France. Observers in many parts of Europe were found who have taken a deep and enthusiastic interest in the experiment, and as a result of the trip so much material has been received at the North Saugus laboratory as to demand a great extension of laboratory space.

Especial efforts were made during the late spring and early summer of 1907 to arrange for the importation of larger numbers of the egg parasites of both species, and to introduce in living condition the important parasites of the genus *Apanteles*, which, according to the writer's field observations, are among the most important of the European enemies of the gipsy moth. Previous importations of these parasites had failed, owing to the fact that the parasites emerged and died on the journey. The present year, however, specific directions were given to agents to send in young larvæ of the second age, and by this means living specimens of the parasites in considerable numbers have been reared at North Saugus. These on issuing laid their eggs in the gipsy-moth larvæ in their first stage. From these caterpillars were secured the cocoons and adults of a second generation, which was reared through all of its stages on American soil. It is hoped to repeat this experience on a more extensive scale next year, and thus to secure a very large number of the adult parasites for colonization.

Moreover, the important experiment has been tried this summer of rearing from the imported brown-tail nests a very large number of caterpillars which gave out in their later growth a second lot of parasites entirely different from those reared in May from the very young hibernating larvæ. Among these were at least two species of the important parasites of the genus *Apanteles*.

Another important result of the work of the early summer is the rearing from imported brown-tail nests of a parasite of the genus *Meteorus*. From the larger caterpillars a second generation has been reared after a very brief interval, the cocoons appearing in about ten days in cages in which the adult parasites were confined with their host insects. This indicates a very short breeding period during the summer time, and although this parasite has not been reared in great numbers its quick breeding indicates that it is a very desirable introduction. Probably the same species was occasionally found in boxes in which the nearly mature brown-tail caterpillars were shipped, and a few emerged from some of these caterpillars, which arrived alive and in apparently a healthy condition. After the parasite emerges the larger caterpillars seem as though they were not fatally affected by the work of the parasitic larva, but all have died without transforming. The species of this genus *Meteorus* on occasion may become very effective; a native species, for example, has been known to destroy 90 per cent of the larvæ of a native moth infesting the western pines.

In addition to the sending of brown-tail hibernating nests above referred to, during the fiscal year ending June 30, 1907, there was received from Europe a total of 1,375 boxes containing the matured

caterpillars and pupæ of the gipsy moth and the brown-tail moth. Of these, 872 boxes of the brown-tail were received during June, 1907, and 82 of the brown-tail and 425 of the gipsy during July and August, 1906. The percentage of parasitism varies considerably, according to the different localities from which the nests were sent, but it must be remembered that in these European localities the percentage of parasitism is constantly fluctuating, being smaller in some years and almost exterminative in others. A part of the parasites sent over do not emerge from the caterpillars or pupæ until after they arrive at North Saugus; others are found in the boxes in the pupal condition, and a few, especially toward the latter part of the season of sending, transform into adults and die on the journey.

Of these parasites, about 90 per cent have been tachinid flies, and perhaps 12 species have been reared from the two host insects, most of them being common enemies of both species. About 40 per cent of these flies emerge as adults at nearly the time of the emergence of the moths of the species which they attack, while the remainder pass the winter in the pupal condition, emerging the following spring. Seventeen hundred adult tachinids were colonized in July and August, 1906, and more than 2,000 during June, 1907. It is now obvious that a very large number will be on hand hibernating during the winter of 1907-8, and the problem of caring for them is a serious one. They are considerably parasitized by hymenopterous, secondary parasites, so that it will be necessary to keep them well protected, at the same time under conditions as near the normal as possible. At the close of the fiscal year between 6,000 and 7,000 puparia were already on hand. With one of the smaller species of tachinids breeding experiments were very successful, and the species reproduced freely under these conditions, indicating that it will be the part of economy to handle it in this manner, liberating only after having bred large numbers.

The large predatory beetles of the genus *Calosoma*, referred to in previous reports, have been successfully introduced in considerable numbers. *Calosoma sycophanta* was discovered in several of the field colonies in the spring of 1907, having established itself, survived the winter, and reproduced. It is a valuable importation, but whether it will prove in itself sufficient to reduce the numbers of the gipsy moth and the brown-tail moth to an appreciable extent is undetermined.

In the report for last year the writer drew particular attention to two species of the genus *Pteromalus*, small parasites of the superfamily Chalcidoidea. Some 60,000 were reared in the early summer of 1906, and the great majority of them were liberated. That the species has established itself, at least temporarily, has been shown by the fact that specimens were bred in the spring of 1907 from nests collected in colonies of the year before. Throughout a considerable portion of the territory directly north of Boston, within which all of the larger colonies were planted last year, the caterpillars of the brown-tail moth died very generally from a fungous disease, and as a result there was a scarcity of the hibernating nests. Therefore, it was not considered desirable to collect for breeding purposes many of these nests, and it is confidently expected that the species will be found more abundantly in the collections of nests made next winter.

Several new colonies have been planted in quite widely separated localities.

The difficulty of determining the exact names of these European parasites, nearly all of which are very common members of the European fauna, is scarcely to be believed. The two species of *Pteromalus*, for example, mentioned in the last report have been a source of great difficulty. The writer was unable to find them represented in the large museums at Vienna, Dresden, Berlin, Brussels, and London, nor did they occur in the type collections of Ratzeburg at Eberswalde, where, on account of that writer's important work on the parasites of European forest insects, one would naturally expect to find them. At last, in the Museum of Natural History in the Jardin des Plantes at Paris, specimens of both species were found that had been reared many years ago by the French entomologist Sichel and had been named for him by the eminent authority on parasites, Arnold Foerster, of Germany. They will, therefore, in the future be known definitely as *Pteromalus nidulans* Foerst. and *Pteromalus egregius* Foerst.

#### OTHER IMPORTATIONS.

What may prove to be an important egg parasite of the imported elm leaf-beetle has been discovered in France, and through the courtesy of two French correspondents, Dr. Paul Marchal, of Paris, and Mr. Ch. Debreuil, of Melun, egg-masses were sent to this country in the hope of establishing the parasite on this side of the ocean. Both sendings, however, were started too late in the year, and the parasites issued during the journey, dying before they could be liberated.

As happened last year, several species of European Coccinellidæ, beneficial in habit, were imported and liberated in the vicinity of the parasite laboratory at North Saugus, Mass. No progress is to be reported in regard to the older importations, the status being practically that of a year ago. During the last European trip of the Chief of the Bureau, arrangements were made for the importation of the European enemies of the codling moth, and these should begin to arrive the coming autumn.

#### EXPORTATIONS OF USEFUL INSECTS.

The official entomologists of European countries have been so helpful to the United States Department of Agriculture in assisting in the various importations of beneficial insects from abroad, and especially in the work on European parasites of the gipsy moth and brown-tail moth, in all cases refusing material compensation, that it is a pleasure for the Bureau to find that it can be of assistance in the way of return favors of like character. During the past year various exportations of certain important parasites of *Diaspis lanatus*, an injurious scale-insect found upon peach, cherry, pear, lilac, and other trees and bushes in the United States, but which is much more injurious in southern Europe, where it attacks the mulberry upon which the prosperity of the silk industry depends, have been made to Italy, where they have been received and cared for by Prof.

Antonio Berlese of the Royal Station for Agricultural Entomology at Florence, and by Prof. F. Silvestri at Portici. Several species of these parasites have been bred in Italy, and it is the expectation of our Italian correspondents that they will be of assistance in holding the mulberry scale in check.

An even more interesting experiment of this sort has been entered into in order to assist the French Government to stamp out a dangerous disease of the dromedary in Algeria. The disease in question is caused by a trypanosome inhabiting the blood, and it is conveyed by tabanid flies. The natural enemies of the tabanid flies in Algeria are not effective, owing to a decidedly diverse period of abundance in the two forms. The United States Department of Agriculture has therefore been appealed to for advice in regard to the sending of American species inimical to the tabanids, which may possibly develop in Algeria in such a way as to control the disease-carrying species. Efforts were made toward the close of the fiscal year to send to France for immediate transportation to Algeria large shipments of *Monedula carolina*, a sand-digging wasp common in the Southern States and which is an effective enemy of American tabanids.

#### INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

The work on forest insects carried on under the supervision of Doctor Hopkins, the entomologist in charge, has been largely in the line of continued work on the projects mentioned in previous reports. Very satisfactory progress has been made, both in acquiring and diffusing information of practical value to the forest interests of the country.

#### WORK ON THE INSECTS THAT PREVENT FOREST REPRODUCTION.

It was found that the principal damage by insects to forest reproduction is caused by certain scolytid beetles which bore into the new cones of the western yellow and other pines and prevent the normal development of the cone seeds. Certain caterpillars belonging to different genera are also found to destroy the new cones or the seed in the old cones of pine and fir; and certain seed parasites of the genus *Megastigmus* often cause an entire failure of the seed crop of the Douglas fir, the balsam fir, and other species. The combined depredations of these insects frequently destroy the seed crop and prevent natural reproduction. There are also numerous enemies of the saplings, including the destructive white-pine weevils, which contribute to the failure of young growth to replace the old. Much has been learned concerning the life histories of these insects, and some of the results have been published in Circular No. 90 of the Bureau and elsewhere.

#### WORK ON INSECTS INJURIOUS TO FOREST PRODUCTS.

The lumbermen and manufacturers in this country, and the consumers in other countries, of certain export material, have shown a great deal of interest in recent years in an insect injurious to crude, manufactured, and finished products. Especial attention has been drawn to the insects affecting seasoned stored and finished hardwood material and the woodwork in dwellings and other buildings. These injuries are caused by a class of insects called powder-post

beetles and are very severe. During the year data have accumulated concerning the habits and life histories of these insects, and much has been accomplished toward the determination and practical application of successful methods of control. These involve the proper management of the material to prevent injury, the destruction of worthless infested material at the proper time to destroy the insects, and the proper and liberal use of pure kerosene both as a destructive and preventive agent—all of which, however, must be adjusted to meet the requirements of the different kinds of wood, classes of material, and species of insects involved. Circular No. 55 gives some preliminary information on the subject, and a special bulletin will be published as soon as some of the important details of the work have been completed.

#### WORK ON INSECTS OF THE BLACK HILLS NATIONAL FOREST.

The work on insects of the Black Hills National Forest was continued during the season of 1906 mainly in completing the study of the seasonal history and habits of the Black Hills beetle and observations on the extension of its ravages; also in the testing of a recently invented tool for the removal of infested bark from standing timber.

Methods had already been recommended by the Bureau to the Forest Service for the control of the ravages of the beetle. These measures would have been effective if carried out. The depredations, however, had extended over such a wide area and such a large proportion of the material was infested that at least 200 men, working several months, would have been required and a much larger expenditure of money, in addition to that derived from sales of timber, than was practicable with the available force and funds at the disposal of the Forest Service; therefore the work was stopped. Unless the necessary radical and rather expensive methods now required are adopted, it seems useless to expend the small amount of money available; and unless some natural enemy appears within the next year or unless radical artificial measures can be adopted at once, practically all of the merchantable timber of the entire forest will be destroyed.

#### WORK ON BENEFICIAL FOREST INSECTS.

A thorough study has been made of the natural enemies of forest insects and a large amount of material has been brought together; interesting and important facts have been ascertained concerning their life history and the possibility of their practical use. The knowledge of this phase of the subject has advanced to a stage where much of important practical value is available for immediate utilization in the introduction of natural enemies or in the adjustment of forest management and business methods for the protection and promotion of these natural enemies.

#### OTHER WORK.

Studies have been made on the relations of environment to injury to forest trees by insects, such, for instance, as the relation of storm-felled trees to multiplication of the insects; the relation of soil and climate to insect depredations, and the relation of drought to the

same subject. The relations of insects and forest fires in the destruction of forests has also claimed especial attention. The contributing of insect-killed timber to the starting and spread of forest fires is an important subject, and studies made indicate that the damage attributed to fire alone may be directly chargeable to insects, although not necessarily in all cases.

A great deal of work has been done on the bark weevils of the genus *Pissodes*; on insects affecting hickory and ash; on insects affecting the black locust; and in the forests of the Northwest, the Pacific coast, the Southwest, the northern section of the Rocky Mountains, as well as in the South and East, special insects have been studied and special problems have been under the observation of field agents. In cooperation with the Forest Service, special explorations have been made of National Forests and private forests, the knowledge possessed by forest rangers being utilized in a number of instances.

Systematic and economic studies of special groups of forest insects have been begun and carried on, and during the winter time field assistants returning to Washington have been engaged in the systematic investigation of problems relating to such special groups of insects.

#### INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The work on insects damaging deciduous fruit trees has been in the main a continuation of the investigations already in progress at the close of the last fiscal year, though additional projects have been undertaken, and the tests of the lime-sulphur washes and other insecticides for the San Jose scale have been concluded.

#### FIELD STATIONS.

The plan of maintaining field stations in parts of the country devoted to the growing on a large scale of deciduous fruits has proved to be a most excellent one, and in this way it has become possible thoroughly to study under perfectly normal conditions the insects which are under investigation, and to conduct tests of remedies on a commercial scale. The work at the respective field stations in the study of a given insect pest and in tests of insecticides, so far as is possible, is carried out according to a uniform plan, so that the results are entirely comparable and calculated to show any variations in the life and habits of the species and what changes, if any, should be made in the use of remedies on account of climate, location, etc.

The field station at North East, Pa., has been continued and two additional men have been assigned to assist the field agent in immediate charge. This increase in force became necessary on account of taking up additional work with certain grape insects to be presently mentioned.

The field station which was maintained during 1906 at Myrtle, Ga., for the study of peach insects was discontinued at the close of the growing season for that year, and the agent there located was transferred in the spring of 1907 to Olden, Mo., to continue investigation of peach insects in the peach-growing regions of the Ozarks.

The field station at Nebraska City, Nebr., for codling-moth experimental work, maintained during 1906, was also transferred to Olden,

Mo., in the spring of 1907, where better facilities are afforded for work on this insect by reason of a larger and more convenient orchard acreage. The uniting of the two lines of work at Olden also resulted in a more complete equipment of the laboratory and of spraying apparatus.

Demonstration spraying in the control of codling moth and apple diseases in cooperation, as during the last calendar year, with the Bureau of Plant Industry of this Department, was begun in the spring of 1907 in southeastern Nebraska and in the Ozark regions of Missouri and Arkansas and in Virginia.

The practically complete destruction of the fruit crop in Nebraska and Missouri by late spring frosts after the work was well under way necessitated an immediate change of plans, and the codling moth experimental work for the Middle West was transferred to Siloam Springs, Ark., where a sufficient apple crop was found. The peach insect investigations in the Ozarks were, on account of the lack of fruit, abandoned. A temporary field station has been located in southern Ohio, where important observations have been made on various deciduous fruit pests.

#### CODLING MOTH INVESTIGATIONS.

The experimental work on the codling moth, beginning May 1, 1906, at Nebraska City, Nebr., was continued to the close of that season, and embraced a thorough life-history study of the insect for that section, and the spraying of a series of plats to show the relative value in controlling the insect of from one to six applications of spray made at various times during the season. The codling moth investigation has been continued, beginning with the spring of 1907, along about the same lines as for 1906, though considerably extended. A detailed life-history study of the insect and investigations of its parasites, etc., with tests of sprays designed to show the number and times of applications which may be most effective, are under way. The transfer of work to Siloam Springs, Ark., on account of the destruction of the fruit crop at Olden, Mo., will not, it is believed, seriously impair the investigations planned.

This insect is also being investigated at the northern field station at North East, Pa., along approximately the same lines as in the South, and also in the vicinity of Washington, representing a more central latitude. This species will also be made the subject of special investigations, beginning the first of the fiscal year 1907-8, on the Pacific coast, as explained under plans for that year.

In addition to the purely experimental work on this insect above indicated, this Bureau, in cooperation with the Bureau of Plant Industry, is carrying out demonstration sprayings in control of the codling moth and apple diseases. This work, under way at the close of the last fiscal year, was continued during the remainder of the season of 1906, and included spraying apple orchards on a commercial scale in several localities in southeastern Nebraska, in Missouri, and Arkansas, the principal results of which have been published in Farmers' Bulletin 283. The work in general resulted in a much greater reduction of losses from codling moth than the growers in these respective sections were accustomed to obtain, and also has

resulted in a great improvement in the methods of preparing and applying sprays on the part of orchardists.

The demonstration spraying planned for the spring of 1907 for the Middle West was much modified on account of the loss of the fruit crop in southeastern Nebraska and Missouri, and the work has been restricted to several points in Arkansas. Similar work, however, is being done in one locality in Virginia, in southern Ohio, and also at North East, Pa. These necessary changes of location in the Middle West interfered with the timely application of the first one or two sprays, but it is hoped that the final results will not be seriously modified.

#### PLUM CURCULIO INVESTIGATIONS.

Next to the codling moth, this small snout beetle is perhaps the most serious of the insects injuring deciduous fruits in the United States, attacking principally plums, peaches, and apples, causing in the aggregate losses of several millions of dollars each year. This species has been under investigation the past two years, especially as an enemy of peaches, the work being conducted at the different field stations and at Washington, but particularly in the Fort Valley section in Georgia, where it is a very important pest of the peach crop. The transfer of the southern station from Georgia, where it had been maintained for two years, to the peach region of the Ozarks, as previously explained, was effected in the spring of 1907, and the work was well begun when the loss of the crop in this section made it necessary to abandon the work for the present. The practical destruction of the peach crop in the orchards available in the vicinity of Washington has also prevented the carrying out of the study of this insect as planned. This project, which it was hoped could be concluded by the close of the growing season of 1907, should be continued another season.

#### PEACH BORER INVESTIGATIONS.

The life history of the peach borer has now been quite fully investigated in the South Atlantic States (Georgia), the Middle Atlantic States (Maryland and Virginia), and the Northern States (western New York and northwestern Pennsylvania), and the period of emergence and oviposition of the moths determined. Similar studies are now being made in Texas, Arkansas, and southern Ohio, the work in Texas being in cooperation with the entomologist of the Texas Agricultural Experiment Station. These studies have shown important differences in the times of appearance of moths in the respective sections and forcibly illustrate the desirability of studying according to uniform plan the same species in different parts of the country. When similar data shall have been secured for the more central of the middle Western States, it is believed that it will be practicable to indicate quite exactly for all parts of the United States covered by its distribution the best period to apply washes and other remedial measures. Along with the life-history studies of this species has gone the testing of numerous washes and other methods likely to be valuable in protecting trees from its ravages. To be reliable, however, and to determine possible injury from their application to the trees, conclusions as to the efficacy of washes must be based on several years' tests.

## SAN JOSE SCALE INVESTIGATIONS.

Work with the San Jose scale has been confined to further tests of various formulas for the lime-sulphur wash, to determine an efficient and economical formula which may properly be recommended for adoption as a standard, as well as many other points connected with its preparation and use. This work was concluded in the fall of 1907 and a formula has been decided upon as best for recommendation, namely, lime 20 pounds, sulphur 15 pounds, water to make 50 gallons, and cooked for one hour. The more important conclusions are included in an article on "Lime-sulphur washes for the San Jose scale," in the Yearbook for 1906, and a more detailed report is now in the course of preparation.

These tests, made in widely separated localities, show that in general a wash properly made and applied is equally effective in all latitudes in the Eastern States and constitutes a cheap and efficient treatment for this pest, which but a few years ago seriously threatened the fruit-growing industry in the East.

Other scalecides have been tried, including the principal proprietary preparations, such as the so-called miscible oils, and some attention has been given to devising washes less troublesome to prepare than is the lime-sulphur spray; but thus far nothing has been found so effective or cheap as the well-made lime-sulphur wash.

The investigation of numerous practical chemical questions concerning the lime-sulphur wash, undertaken in cooperation with the Bureau of Chemistry, has been concluded and reported upon by Mr. J. K. Haywood, in Bulletin No. 101, of the Bureau of Chemistry.

## OTHER WORK.

The testing of various arsenicals on peach foliage, alluded to in the report of last year under the head of "Plum Curculio Investigations," indicated the need of further investigations along this line, and a more extensive study has been undertaken in cooperation with the Bureau of Chemistry, tests being made especially of arsenate of lead and the ingredients used in the preparation of the same to determine if possible the conditions under which injury to the fruit and foliage of the peach is likely to occur, and how if possible this may be avoided. Thus far there is no arsenical or effective poison which it is safe to recommend unqualifiedly for spraying peach trees, and such a preparation is greatly to be desired for the control of the plum curculio.

During the past two years a small moth (*Enarmonia prunivora* Walsh) has frequently been bred from apples from various parts of the country, and an investigation of the habits of the larva shows that in many respects these are quite similar to those of the codling moth; it infests the blossom end of the apple, and the second brood especially eats out patches and burrows on the side and in the blossom end of the fruit, greatly disfiguring it. From the observations already made it is certain that the larva of this species and its work have been mostly confused by entomologists and others in the United States with the larva of the codling moth and its work. This insect must therefore be added to the list of those injuring the fruit of the apple in the United States. A careful study of the species is now being made. It appears probable that the measures effective in controlling the codling moth will also keep this species in check.

The demonstration work in canker-worm control mentioned in the last report has been concluded and a report prepared. An investigation of a lepidopterous borer (*Synanthedon pictipes* G. & R.) of the peach and other plants, heretofore mostly confused with the true peach borer, has been concluded and the manuscript prepared for publication.

#### FIELD-CROP INSECT INVESTIGATIONS.

The work on field-crop insects, under the especial charge of Prof. F. M. Webster, was continued during the past fiscal year with excellent results. Field work was devoted to the carrying on of the Hessian-fly and joint-worm investigations of the previous year, and owing to a serious outbreak of a grain aphid in the Southwest in the spring of 1907 the investigation of this last insect assumed great importance.

#### HESSIAN-FLY INVESTIGATIONS.

The wheat-sowing experiments indicated in previous reports were increased during the year in cooperation with the New York, Pennsylvania, and Tennessee experiment stations. These sowings, now numbering over 800, are being carried on at present in eleven States. Exact data are being continually accumulated, showing that it is possible to evade the most serious portion of the fall attack of the fly by seasonably late sowing in the fall. These experimental sowings, which are carried out almost exclusively by the very best farmers, are veritable object lessons, are attracting much attention, and are carefully watched by the farmers throughout the sections where the experiments are conducted.

Work on the Hessian fly in the spring-wheat sections has been continued, and last year's results have been verified. Many new facts have been secured regarding the life of the pest in this new region, and the chief parasite—a *Polygnotus*—has been followed through its life round. The possibility of the practical use of this parasite has been shown in two interesting cases. Early sown plats at Lansing, Mich., and Marion, Pa., were very seriously attacked by the Hessian fly, but when examined carefully at a later date fully 90 per cent of the "flaxseeds" (pupæ) were found to have been stung by *Polygnotus* and to contain its developing larvæ. A field of wheat near Sharpsburg, Md., was found to be infested by the fly, and examination indicated the absence of the parasite. On April 8 a large number of the parasitized "flaxseeds" from Marion, Pa., were brought to Sharpsburg and placed in the field. On July 8 an examination of the Sharpsburg field showed that the parasites had taken hold to such an extent that of the large number of "flaxseeds" taken and brought to the laboratory for investigation not one was found which had not been parasitized. Careful observations of the habits of this parasite in Kentucky, Tennessee, and Alabama have been made, and the observations and collections made in the autumn of 1906 in western Kentucky and northern Alabama have been of material aid.

#### INVESTIGATIONS OF THE SO-CALLED "GREEN BUG."

The insect known to the farmers in the Southwest as the "green bug" is really an aphid known as *Toxoptera graminum*. It occasion-

ally appears in enormous numbers and causes great damage to small grains. Early in January the insect was reported from eastern central Texas as attacking fall oats. In the area mentioned the temperature was  $9^{\circ}$  to  $12^{\circ}$  above the normal. About the same time, as was later shown, it began to breed rather rapidly in fall-sown oats in southern South Carolina, the temperature at the time being from  $6^{\circ}$  to  $9^{\circ}$  above the normal. During February the region west of the Mississippi and the Great Lakes was warmer than usual, and during this month much damage seems to have been done in Texas. On March 6 the insect was first reported from Arkansas, and an agent was immediately sent to the field to experiment with measures for destroying the insects in the field, especially over the spots where they seemed to be most abundant, and to determine what could be accomplished in checking the ravages of the pest by the early introduction of its natural enemies into the infested fields. On March 18 several boxes of parasites reached the Arkansas fields from an agent of the Bureau in Texas, but local parasites were already there in great numbers, and further importation of parasites was useless; the "green bugs" were evidently about to be destroyed. The agent then proceeded to various points in Oklahoma, but at Chandler and Guthrie the local parasites were already practically in control. At Kingfisher the parasites were found less plentiful, and parasites were at once introduced in great numbers from Texas and Oklahoma. Proceeding farther, the agent reached Wellington, Kans., on March 30. In the next week thousands of parasites were brought from Oklahoma and liberated. On April 9 it is estimated that more than two and a half millions of parasites were liberated in a single wheat field near Wellington. This was done in order to make a decisive test as to whether it is possible to aid in protecting fields in this manner along the advance line of invasion of the "green bug." The weather was still cold, and it was thought that if the artificial introduction of parasites would, with the return of warmer weather, hasten the control of the Toxoptera, the introduction of a large number would clearly demonstrate this fact; and if such an introduction on a large scale proved favorable it would show a reasonable ground for a more general introduction of parasites in lesser numbers. The weather during the whole of April was generally cold, with an occasional storm that is known to have killed many of the parasites, and though there were brief periods of warm weather during which the parasites would increase rapidly, the Toxoptera was not overcome in southern Kansas until about the middle of May. The weather conditions were almost universally unfavorable to the parasite and therefore favorable to the development of the "green bug." Two agents stationed near Wellington and in northern Oklahoma were constantly watching a wide range of country, and the results indicated that the local parasites developed in other places, aside from the experimental field near Wellington, about as rapidly as in the field where the two and a half millions were liberated. No benefit in this field was indicated above other fields, near or remote, where no artificial introductions were made. Minor introductions were made at McPherson and at other points, and in no case was there a field of the hundreds examined in southern Kansas where the number of parasites natively present did not outnumber by many

thousands or hundreds of thousands those liberated artificially at a time when weather conditions had become such that the liberations could have had any benefit. When weather conditions became favorable, parasites were abundant in equal numbers in all fields. The weather is the important influence, and without favorable weather artificial introduction of parasites does little good in the case of this insect.

On May 13 Professor Webster visited the field and conducted a further experiment in this direction, with a view to hastening the work of the parasites during favorable weather by large introductions. Two fields of oats near Manhattan, each containing 4 acres, were selected. These fields were sufficiently widely separated. One of them was used as a check, and into the other were introduced very great numbers of parasites sent from Wellington. Careful count showed that in these fields the percentage of native parasitism at the beginning of the experiment was from 3 to 7. On May 18 many hundreds of thousands of parasites were liberated in one of these fields. On May 23 in this field the parasitism had increased only about 2 per cent, whereas in the check field, in which no parasites had been liberated, it had increased 12 per cent. On May 27 the percentage of parasitism in the field into which the parasites were introduced had reached 27, while in the check field it was 32. It was thus clearly demonstrated that, even under weather conditions favorable for the development of the parasites, an introduction to the extent of millions carried out under field conditions does not indicate enough efficiency to afford any encouragement for the use of this measure in the protection of the grain fields in case of future attack. It seems that with all the artificial introductions of this parasite that were made in the spring in grain fields of Kansas and the adjacent States and Territories there is no probability that a single bushel of grain was saved by such introduction. Similar substantiating experiments were conducted in North Carolina and Virginia. Careful study was made of the life history of the most important of these parasites, a minute braconid of the genus *Lysiphlebus*.

Extensive experiments were made with mechanical artificial remedies. Owing to the fact that the insect usually makes its appearance numerously in spots and spreads rapidly from these places, it becomes desirable to know some method of quickly destroying it in the spots first attacked, even at the sacrifice of that portion of the crop in order to protect the rest of the fields. It was shown that these spots can be treated successfully by plowing under and then harrowing and rolling the surface of the ground, by spreading straw over them and burning, or by treating with a 10 per cent solution of kerosene emulsion. In the southernmost regions infested by this pest, however, the greatest difficulty does not seem to arise from these isolated spots, which seem to extend outward from day to day, but from the fact that, after their food supply has become either largely destroyed or the grain is too old and tough for them to feed upon, immense swarms of winged adults are produced, and these drift in general northward with the advance of the season and infest the grain fields of entire sections of the country much earlier and more completely than would be possible from the scanty stock natively present. This habit is also seen in the behavior of the pest

in its original home, in Europe. It may therefore prove that the country north of the Red River may be more or less protected if the pest can be early overcome in northern Texas.

#### JOINT-WORMS AND OTHER GRAIN INSECTS.

Some work has been done with an important enemy of the wheat joint-worm, and investigations of the timothy joint-worm have been continued. It is shown that the damage to the seed of timothy by the action of this insect is greater than the damage to the hay crop. Rotation of crops seems to be the most practical preventive measure with both of these insects.

Further investigations have been made on the seed-corn ground-beetle and the corn root-aphis and a number of other insects belonging to this group.

#### WORK ON INSECTS INJURIOUS TO VEGETABLE CROPS.

The work on insects injurious to vegetable crops, under the charge of Dr. F. H. Chittenden, has been somewhat developed during the past year. Especial attention has been given to insects affecting this class of crops in the Southern States and to the insect enemies of the sugar beet in the West.

#### INVESTIGATIONS IN THE SOUTHERN STATES.

A special agent was sent to southern Texas in March to establish headquarters in Corpus Christi, where work was begun upon such prominent southern pests as the bollworm in its occurrence upon tomato and other truck crops. The onion thrips was the subject of special study in its occurrence on onions. Cooperative demonstration work against the melon aphis was carried on as in the previous two years with the Texas Agricultural Experiment Station, and studies were made of three species of leaf-beetles which affect cucurbitaceous and other truck crops.

A similar line of investigations was conducted by an agent in Florida, who, however, did not begin work until May, and whose investigations must be considered simply as preliminary. The species which have so far formed the subject of special investigations in this region are the pickle worm, imported cabbage webworm, and the melon aphis. A study has been begun of the natural enemies of the melon aphis, looking to a possible exchange with the Texas Agricultural Experiment Station, provided insect enemies are found in one State that do not occur in the other.

Study was also begun of the cabbage looper, the grass worm in its occurrence on sweet corn, a destructive cutworm, plant-bugs, flea-beetles, and certain other species.

#### ENEMIES TO THE SUGAR BEET.

The scope of the investigation of the insect enemies of the sugar beet, which have been under continuous observation for a number of years, was augmented by the employment of a special field agent in cooperation with the Utah State Agricultural Experiment Station to study the principal pests found in Utah, Idaho, and Colorado. A destructive leaf-hopper (*Eutettix tenella*), known in that region as the white fly or blight and as the supposed author of "curly leaf"

from the effect of its injuries to beets, has received special attention, and an extensive account of its life history and habits has been prepared and is available for publication. The publication when completed will contain also short notices of related species occurring in the same regions, together with suggestions for the control of leafhoppers.

In the autumn of 1906 a temporary field agent was employed to investigate the local conditions of sugar-beet insects of southern California. Especial attention was given to the beet aphid, flea-beetles, and the leaf-beetles.

#### OTHER INVESTIGATIONS.

A number of other important species occurring upon truck crops have been under observation, and a bulletin has been published on the asparagus miner and the asparagus beetles.

#### WHITE FLY INVESTIGATIONS.

For some years there has been a desire on the part of important interests in Florida to have the Department undertake a new and thorough investigation of the injury by the white fly to citrus fruits in that peninsula. The white fly has for many years been one of the greatest obstacles to the success of the citrus industry in Florida, and has been studied by the Bureau of Plant Industry from the standpoint of the sooty fungus which follows it, and by this Bureau from the life history side and means of control. A preliminary survey of the territory was made in 1905, but no appropriation for extended work was available until the fiscal year beginning July 1, 1906, when Congress specifically designated \$5,000 for this investigation. This work has been under the direction of Mr. C. L. Marlatt, Assistant Chief of the Bureau, with Mr. A. W. Morrill, special agent, in field charge, with headquarters at Orlando, Fla., assisted at various times by men temporarily transferred from other investigations, and by a special appointee, Mr. Stephen Strong, for two months as fumigation expert from California.

The white fly is an important pest throughout the Gulf region, and this year has been found fairly well established about Marysville, in California. This California outbreak was entirely unexpected, as the climate of the Pacific orange districts is distinctly unfavorable to this pest. The white fly requires a considerable rainfall or humidity, and there is reason to hope, therefore, that the California outbreak is a temporary one, induced largely by a season of exceptional rainfall and moisture in the region designated. As a matter of fact, radical measures instituted by the State Horticultural Commission have apparently eradicated the pest.

The work done during the year with the white fly in Florida includes (1) life history studies; (2) natural control, i. e., by parasitic insects or fungous diseases; and (3) control by the use of insecticides or by "gassing."

While the life history of the white fly has already been pretty carefully worked out in its main details in the earlier work done with this insect, still much information of distinct value is resulting from the present more thorough and detailed study. The greater part of the year covered in this report was one of unusual drought in Florida,

and it has had the general effect of greatly reducing the abundance of the white fly and is confirmatory of the fact, stated above, of the dependence of this pest on a considerable amount of moisture. With the return of normal conditions, however, the pest is now rapidly increasing to its usual status.

One of the most important factors for the natural control of an insect like the white fly is parasitic enemies; but unfortunately the white fly in Florida seems to be devoid of true parasites. Efforts are being made, however, to obtain parasites of other species of the same genus (*Aleyrodes*) to which the white fly belongs, and to introduce these into Florida in the hope that some of these may eventually become important means of control. There are many species of *Aleyrodes*, and some of these in different parts of this country and in foreign countries seem to be controlled by parasites. Several native predaceous insects have been found to prey upon various stages of the white fly, but thus far they produce no important check.

The most useful natural-control agencies are parasitic fungi, which have, especially in the southern range of the white fly, been often of very great service in checking it and which sometimes almost exterminate it for a period. In Manatee County, where the two important species of fungous enemies have been longest established, they result on an average of one year in three in checking the white fly sufficiently to free the trees and fruit from the sooty mold which follows white fly attack, and all the time reduce the amount of injury very much. The investigation of these fungi, and particularly the determination of means of experimentally increasing their range and efficiency, is one of the most important of the problems connected with the white fly work. The benefit from them is especially noticeable in regions with a high degree of humidity, but from the present examination of the subject it does not seem likely that they can ever be made equally effective in the drier citrus regions in Florida.

A good deal of insecticide work has been done in Florida in former years against the white fly, principally, however, with liquid sprays, such as resin wash and kerosene emulsion. No such work, however, against the white fly is effective unless it is general, as the insect flies readily and is carried by winds from one orchard to another, so that it spreads much more quickly than is the case with scale insects. While spraying has been practiced to a great extent in Florida, it has been irregular and often fails to give satisfactory results. A thorough investigation of the use of liquid sprays is in progress.

The use of hydrocyanic-acid gas has not been adopted in Florida to any extent, but the necessity of thorough work on trees would seem to indicate the great desirability of this method of control of the white fly. To take advantage of the large amount of practical experience which has been gained during many years in California in gassing citrus trees, the services of Mr. Stephen Strong, one of the horticultural commissioners of Los Angeles County, were secured for two months last winter to introduce and superintend the hydrocyanic-acid gas fumigation in Florida. The results already reached from these experiments indicate that under favorable conditions— isolation from other infested groves or where concerted action can be had—fumigation is more economical than spraying, and much more certain in its results than reliance on natural enemies.

There has been no official publication during the year giving the results of the investigation, but articles by Mr. Morrill covering special features of the work have been published in the agricultural press of Florida, and a paper was presented before the Southern States Association of Commissioners of Agriculture and also before the Florida State Horticultural Society.

#### INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

##### MOSQUITOES AND HOUSE FLIES.

Work has been continued on the Monograph of the Mosquitoes of North and Central America and the West Indies, and a skilled agent has been sent to Panama, in cooperation with the Isthmian Canal Commission, to study the mosquitoes of the Canal Zone, with especial reference to the geographic distribution and breeding conditions of the species that carry disease.

No further work on the house fly has been done, but extensive correspondence has been carried on with individuals and with boards of health. A revised edition of Circular No. 71 of the Bureau has been published and widely distributed.

##### WORK ON THE TEXAS CATTLE TICK.

The importance of the extermination of the cattle tick has recently been brought prominently to public attention. Absolute extermination seems feasible. The work on the life history and habits of the tick, on which means of eradication or control must be based, falls naturally within the province of the Bureau of Entomology, while the eradication or control work itself is carried on by the Bureau of Animal Industry. Some good work on life history and habits has been done by a few of the State officers of the South, but this work has been far from commensurate with the magnitude of the problem. As indicated in the last annual report, a beginning was made in the study of the tick at the urgent request of many experiment-station officers and cattle raisers of the South. This work was done in connection with the cotton boll weevil investigation, and necessarily could not be of an extensive character. Nevertheless the experiments and observations made during the year revealed many points of practical importance. The results are soon to be published in a bulletin by the Bureau. The work under way is designed to show the variations in the development of the tick on the hosts and the duration of the period passed on the ground. The interrelationship between these periods is the most important matter that must be taken into consideration in formulating plans for control. The principal work under the Bureau is being done at Dallas and Victoria, Tex. The longevity of seed ticks is being tested and the probable duration of the egg stage under various conditions. Cooperation has been obtained with experiment stations, and notably with the Tennessee station.

In connection with the study of the cattle tick, it has been possible to make observations on a number of other species of ticks that are now of considerable importance as animal parasites. Some of these

may assume much greater importance if they are found to be concerned in the transmission of disease. In this work several species not known previously to occur in the United States have been taken by agents of the Bureau, and notes have been made on their life history and means of control. Other species known to occur in the United States, but which have not been carefully studied, are receiving attention.

#### WORK ON SCALE INSECTS.

The principal scale pests are in evidence every year, and even the San Jose scale has become so thoroughly well known and understood that its steady extension causes no special excitement. Practical control by remedies is becoming more efficient every year. Some special work with insecticides against it has been referred to in another place. The requests for information on this and other orchard scale pests are a steady and considerable factor in the correspondence of the Bureau. Among the scale pests which are not strictly orchard or small-fruit species several have been especially complained of during the year. For example, the magnolias in the Gulf States seem to have been badly infested with a *Lecanium* soft scale, *Toumeyella turgida* Ckll. Another species of this genus, *Toumeyella pini* King, appeared in injurious numbers on young seedling pines in several eastern nurseries. The soft scale of the tulip tree is reported to be damaging tulip and magnolia trees in various localities in the Eastern States. A common West Indian scale pest, *Asterolecanium pustulans* Ckll., is gaining a foothold in the vicinity of Miami, Fla., on oleander, fig, mango, and other plants. *Pulvinaria pyriformis* Ckll., also a West Indian scale affecting guava, cinnamon, and Persea, has been found in Florida on cinnamon trees, this being the first record of the species for the United States. The cottony maple scale (*Pulvinaria innumerabilis*), referred to in a former report as having been so generally prevalent during the last three years, seems in great measure to be under the control of its natural enemies, and very few complaints have been received this year of damage by this insect. This native species, as pointed out in earlier reports, is one that seems to have a periodic habit produced by the action of natural enemies. Just now, fortunately, we are apparently entering into a period when such natural control is efficient.

#### EXPERIMENTAL WORK WITH INSECTICIDES.

With the broadening of the work of the Bureau and its separation into definite investigations, the experimental work with insecticides becomes naturally more or less divided and assigned to the different fields of entomological research.

The profit from insecticide applications is marked in the case of the insect enemies of the deciduous orchard fruits and of small fruits, and the following experimental work in this field is under way or has been completed: (1) A careful testing of various formulas of lime-sulphur washes for the San Jose scale, carried out in three distinct latitudes and extending over a period of two years. In connection with this work several other substances of possible value against the San Jose scale have been tested, including the

miscible oils. (2) A thorough testing of the effect of various arsenicals, with and without lime, on the foliage of peach, was begun in the spring of 1906, and is being continued this year. (3) In cooperation with the Bureau of Chemistry, an examination is being made of as many brands as possible of arsenate of lead collected from various sources in the open market, and also an investigation of the method of preparation and proportions of the ingredients. (4) In connection with the investigation of the codling moth, the peach borer, and other fruit insects, washes commonly employed are being tested, together with various new combinations.

As already stated, the white-fly investigation of the Bureau in Florida has led to an examination of the possibilities of introducing into Florida the gassing method so long the standard means of controlling scale insects on citrus fruits in California, and some very careful preliminary experiments have been made. The results are very favorable, and the outlook now is that gassing can be made effective against the white fly. This work, however, has only been begun, and the investigation will be continued the coming fall and winter. The work in Florida will be conducted in cooperation with and as a check on the careful investigation of the whole question of gassing citrus trees which is to be instituted with the fiscal year beginning July 1, 1907, in southern California.

The effect of gassing on the eggs of such scale insects and aphides as hibernate in the egg stage, or pass a considerable resting period in the egg stage, is a subject of the greatest practical importance, and particularly in the fumigation of nursery stock and of new or other plants imported from foreign countries. Hydrocyanic-acid gas has been demonstrated to be the most effective and sure means of destroying scale and other insects on nursery stock or other shipping plant material; but unless it also kills the eggs under the conditions noted the protection is necessarily faulty. This whole subject has been taken up for careful investigation, and some preliminary experimental work has been done with the scurfy scale and the oyster-shell scale, and the apple aphid, all of which winter in the egg stage. Results indicating the requirements of fumigation for this purpose will probably be reached by the end of the next fiscal year.

In connection with the other special lines of work of the Bureau, more or less insecticide investigation has been carried on with stored grain pests, insects affecting cereals, and those affecting shade trees and ornamental plants.

The examination of new remedies for insect pests, and the reports thereon, which are presented to this office from all parts of the United States and from foreign countries with almost every mail, is a part of the regular routine. The active work being done with the boll weevil, the gipsy moth, and the San Jose scale evokes innumerable suggestions, very generally, however, from people who have had no acquaintance with the underlying needs, and therefore in ninety-nine cases out of a hundred these suggestions are either valueless or a repetition of methods already in common use.

#### INVESTIGATIONS OF INSECTS AFFECTING TOBACCO.

In the bill making appropriations for the Department for the fiscal year ending June 30, 1908, a clause was inserted providing for investi-

gations of insects injurious to tobacco in the dark-tobacco belt of Tennessee and Kentucky. Unwilling to wait until the beginning of the fiscal year before commencing this apparently important investigation, the Bureau sent an expert assistant to the region late in May to make a preliminary examination of the field. He visited Springfield, Tenn., and made examinations along the road from Springfield to Clarksville, Tenn., at Hopkinsville, Ky., and along the road from Guthrie, Ky., to Russellville, Ky.

Some studies were made of the tobacco flea-beetle, which seems to have been especially injurious this year, of cutworms, of aphides, and of a few other species. Experimental plats in Springfield and Clarksville, Tenn., were arranged for, and cooperation with the Tennessee and Kentucky experiment stations was also arranged. A permanent special agent was placed in the region in question at the beginning of the present fiscal year.

#### INSPECTION WORK.

The Department of Agriculture, through the activities of the Bureau of Plant Industry, has become perhaps the largest importing agency of new stock in the United States. Much of this material comes from quarters of the world which have never been explored entomologically and from which there has been naturally very little commerce in plant material, and therefore all such material is very apt to harbor insect pests new to this country. The worst insect pests of America are those of foreign origin, as illustrated by the San Jose scale, the codling moth, and the black scale in California. To prevent, therefore, the introduction of new important pests, all the plant material imported by the Department of Agriculture is given most rigid inspection by Mr. J. G. Sanders, who has been put in charge of this work. During the year, 916 lots of imported plants were inspected for dangerous insects, the largest of these containing over 5,000 plants. Many of these lots of plants and seeds have been fumigated, and whenever fumigation was impracticable or for any reason inefficient the shipments found infested have been destroyed.

All plants imported from foreign lands or home-grown sent out by the Department of Agriculture are inspected, fumigated, and cleaned, if necessary, before a certificate is granted. Since July 1, 1906, 581 certificates have been issued for the shipment of plants from the greenhouses of this Department.

In connection with this inspection it was very interesting to find the San Jose scale (*Aspidiotus perniciosus* Comst.) very scatteringly present on twigs of pear and apple which had been shipped to the Department from the interior of northern China, notably from Manchuria, by Mr. Frank Meyer, agricultural explorer. The finding of this scale insect scatteringly on these plants is an important confirmation of the results of the exploration by Mr. Marlatt and the determination by him of this very region as the original home of this great pest. The scattering nature also of the infestation would indicate the control locally of the scale by native parasites and predaceous enemies or diseases, and makes it desirable at some future time to have this whole region carefully explored for parasites or other means of natural control of the San Jose scale.

On twigs of pear from Manchuria was found a peculiar new species of *Parlatoria* which, from the known habits of the group of scale insects to which it belongs, might easily prove to be as bad a pest as the San Jose scale. To preclude any possibility of the introduction of this dangerous scale, all the infested scions were burned, and all other woody material strongly fumigated three times.

#### WORK IN BEE CULTURE.

During the past fiscal year the work in apiculture has been reorganized, Dr. E. F. Phillips having been placed in charge, and the facilities for the work materially increased.

The chief problem taken up was the investigation of the brood diseases of bees. The principal hindrance to the greatest possible advance of apiculture in this and other countries is the fact that the bee is subject to several diseases, which are widely distributed, and which constitute often a prohibition and always a hindrance to progress. It therefore has seemed best to devote considerable time to this investigation.

At the very beginning of the year the apicultural expert took an extended trip through California, Wisconsin, and Michigan for the purpose of studying the spread of the disease and the methods used by various practical men in its treatment. It was quite evident that there was need for a short publication outlining the symptoms of the various diseases and the treatment, and consequently Circular No. 79, *The Brood Diseases of Bees*, was prepared and has been widely distributed.

Dr. G. F. White, then of the Bureau of Animal Industry, offered for publication a paper entitled "The bacteria of the apiary, with special reference to bee diseases," which had been prepared by him as a thesis at Cornell University. This paper deals with bacteriological work on the brood diseases of bees, and also contains an account of the normal bacterial flora of the apiary. It was published as Technical Series No. 14.

The work of Doctor White, as well as that of other investigators, made it desirable to take up for consideration the names to be used for the various diseases. Much confusion existed and still exists in some quarters. After consulting by correspondence with some of the leading bee keepers of the United States, it was finally decided to adopt the name American foul brood for the prevalent brood disease of the United States which had hitherto been called simply foul brood and the name European foul brood for the disease known as black brood. These names have been adopted by the bee journals of the United States.

To bring about greater cooperation among the official inspectors of apiaries as well as to spread knowledge concerning the brood diseases of bees, a meeting of inspectors of apiaries was held at San Antonio, Tex., November 12, 1906, under the auspices of this Bureau. This meeting was well attended and attracted considerable attention among persons interested in bee-disease work. The proceedings of this meeting have just been issued as Bulletin No. 70 of this Bureau.

At the San Antonio meeting the Bureau of Entomology was requested to make a study of the workings of the various laws now in force for the control of bee diseases. To aid in this work a list of questions was sent out to all the official inspectors asking them

about the results obtained by them under various provisions of the law; information has also been gathered from all other possible sources. This material is now being gathered together.

Following the San Antonio meeting a similar meeting of the California inspectors of apiaries was held, December 8, 1906, under the auspices of this Bureau.

Whenever possible the apicultural expert and the special agent in California have gone out with the inspectors on their trips. Some new points may always be gleaned from the better inspectors and these are in turn given to those less able to control the situation. While this has been done only incidentally, it has seemingly resulted in considerable good.

Several investigators in Europe have been at work on bee diseases, but because of inadequate descriptions of the diseases and of the organisms found in them great confusion exists. It is essential that the organisms causing bee diseases in this country be known. To provide for this part of the work a small bacteriological laboratory was installed in the spring. The first problem to be taken up was the devising of media suitable for the cultivation of micro-organisms which are present in diseased material; the usual laboratory media are not entirely satisfactory and certain of the organisms found fail to grow on them. A medium of filtered bee larvæ has been made on which *Bacillus larvæ*, found in American foul brood, grows freely. This bacillus does not grow on media made of beef. It was also necessary to devise methods for making test inoculations, and in this respect also the results are proving satisfactory. It has been determined that *Bacillus larvæ* is the cause of American foul brood. For the first time this disease has been produced by feeding pure cultures. The details of the media and inoculation methods, as well as the results of the preliminary inoculation experiments, have been published as Circular No. 94 of the Bureau. In connection with this work a large number of samples of diseased brood have been received, and information has been sent out as to the kind of disease present.

The work on "paralysis," a disease of adult bees, has been continued in California. To test the theory that this disease is caused by poor strains of bees, some apiaries in the diseased district have been stocked with queens of good strains. It is too early to tell what result may be expected. So far no evidence of the influence of a microorganism has been found.

The distribution of breeding material of the various less known races of bees was carried on during the summer of 1906, with the result that these races are now offered for sale by various competent breeders. This method of distribution is much more satisfactory than was the promiscuous distribution of former years, which was greatly misunderstood by bee keepers. For the present this distribution on the part of the Bureau has been discontinued.

The work on honey-producing plants has been continued at the substation in California as far as time would allow. Several valuable honey-producing plants have been sent to various parts of California to be tested under the direct supervision of the special agent. Arrangements have also been made to send some of the principal honey-producing plants of the West to the Hawaiian Islands for testing.

To test the comparative value of the various races of bees in fertilizing red clover, a series of cages has been erected to exclude all other bees. This experiment is of interest not only in regard to clover fertilization but also in studying various things connected with the habits of bees.

A list of the honey-producing plants of the United States has been begun which will prove very valuable in future investigations along this line.

The enactment of the food and drugs act, June 30, 1906, proved of great interest to bee keepers and promises to be of great assistance to them in preventing, or at least limiting, the amount of adulteration of extracted honey. In the Hawaiian Islands there was last year produced about 400 tons of "honey-dew honey." Previous to January 1, 1907, this product was sold as honey and with no qualifying clause. During the present calendar year this office had considerable work to do in regard to the method of selling this product in the United States markets, and finally a satisfactory arrangement was made whereby it is to be sold as "honey-dew honey." Several other important problems connected with bee keeping in the Hawaiian Islands have been considered, and more work will be done during the fiscal year 1907-8.

To further the work of detecting the adulteration of honeys, a large number of samples of pure honey from known sources has been collected by this Bureau and has been analyzed by the Bureau of Chemistry of the Department. The results of this work will be published shortly by the Bureau of Chemistry.

In order to find out the status of bee keeping in the New England States the Bureau is engaged in a detailed study of bee keeping in Massachusetts. Every bee keeper whose name can be obtained is asked to answer certain questions regarding the industry in his own town and to give certain information regarding his own apiary. The percentage of replies is extraordinarily large. This not only enables the Bureau to get detailed information which could otherwise be obtained only at great expense, but it has aroused considerable interest in the industry and promises to result in considerable good by putting the publications of the Bureau into the hands of the proper persons. In advancing bee keeping as an industry it is quite desirable to make the persons now engaged in the keeping of bees better bee keepers rather than to induce a greater number to engage in apiculture.

That bee keeping could be carried on to a much greater extent in many sections of the country is quite obvious; it is also a well-known fact that the United States does not now produce enough honey to supply its own market. It is very desirable, therefore, that the industry be advanced by the introduction of the latest and best methods. The work which the Bureau is now doing in Massachusetts is demonstrating the discrepancy between apiculture as it now is and as it may be, and further, it should show how much good may be accomplished by communicating directly with interested persons to bring to their attention desirable information.

This work is being done in Massachusetts because of the fact that it was possible for the Bureau to get as a collaborator in this work Mr. Burton N. Gates, who has been for some time interested in the industry in that State. If the future results are what they now

promise to be, an effort will probably be made to extend the work to other States. At any rate the work will demonstrate the possibilities of the method.

A detailed study of bee keeping in the Hawaiian Islands has recently been begun by Mr. D. L. Van Dine, entomologist for the Hawaii Experiment Station. This work was begun by Mr. Van Dine as an official of his station, but it is to be continued under this office. There are certain things connected with the industry on these islands which make the work of interest not merely to the bee keepers of Hawaii, but equally to bee keepers of the mainland, and it is desirable that this be done under this Bureau.

#### WORK IN SILK CULTURE.

No changes have been made in the methods that have been followed for some years in the effort to encourage the production of silk in the United States. The interest during the past fiscal year, judging from correspondence, has fallen off. It has been retained to a considerable extent in New York, Pennsylvania, California, Illinois, Missouri, and Texas, but in the other States the interest in this line of work has lessened. It is probable that this falling off in correspondence is due to two factors. The first is one that was pointed out last year—the lack of newspaper and syndicate articles which tend largely to advertise silk culture. Heretofore there has been an abundance of such articles spread from one end of the country to the other, but this year not a single syndicate article appears to have been published. The second factor is lack of interest, furthered by the prosperous condition of the country, which makes larger returns from other lines of work a natural consequence. The returns from silk culture are necessarily small, and it has been the aim of the Department to interest mainly individuals otherwise nonproductive, or those who might make it a small side issue to other farming operations. Should there come a check to the country's prosperity, it is probable that interest in silk culture would immediately revive.

#### PURCHASES OF SILKWORM EGGS AND THEIR DISTRIBUTION.

Eighty-five ounces of bacologically examined eggs were imported from Italy for distribution to applicants in the spring. The shippers carefully marked the package to be delivered to the Government dispatch agent in New York, and placed it in the hands of the steamship agents to be kept in cold storage en route. Instead of following directions, the steamship agents delivered the package to their own house, and after a week's delay in warm weather forwarded it in bond to the Georgetown custom-house, where there was another week's delay in the delivery of the eggs to the Department. They were found, on examination, to be practically ruined, and the matter was placed in the hands of the Department's law officers in order to recover damages, if possible, from the steamship company. A duplicate order was cabled to Europe immediately, and on February 2 the second shipment arrived by the proper channels and was found to be in excellent condition. There were 13 pure and 8 crossed races, making rather a close resemblance to the importations of previous years. They were placed in cold storage and were drawn in small

quantity from time to time as required. One ounce of eggs of four different varieties was purchased from a French dealer, and 1 ounce of Turkish eggs raised at the American Orphanage at Harput, Turkey, was presented by the United States consul at that place. These special lots of eggs were placed in the hands of experienced rearers who have not yet reported. All of the eggs received, with the exception of the first shipment, seemed remarkably healthy and absolutely no complaints have been sent in. There seems to be no pébrine disease existing among the silkworms in the United States at the present time. The previous year it existed at one locality in Cuba.

There seems to have been a certain amount of home production of eggs in spite of the recommendations of the Department that no eggs should be used except those guaranteed free from disease.

The total sendings of silkworm eggs from the Department this year number 343, as against 413 last year. The geographic distribution of the sendings follows rather closely the lines indicated in the discussion of the silk-culture correspondence, California, Kentucky, the District of Columbia, Georgia, Illinois, Indiana, Kansas, Massachusetts, Maryland, Michigan, Missouri, Nebraska, New Jersey, New York, Ohio, Pennsylvania, and Utah receiving the largest numbers. About 74 ounces in all were thus distributed before the close of the fiscal year.

#### DISTRIBUTION OF MULBERRY STOCK.

As in the previous year, seedlings of the best white mulberry from Lombardy and Sicily were distributed to all applicants during the late fall and spring, none being sent out during freezing weather; 10,850 in all were sent out. This is a falling off from the sendings of last year, but to a certain extent some silkworm raisers have received all the seedlings they require or have room for planting. The shipments have been made mainly in lots of from 25 to 50, with occasionally one of a hundred or of several hundreds. Two thousand seedlings were sent to Hawaii. Two kilograms of a good variety of seed were purchased from Milan as a basis for next season's supply of seedlings. These seeds were turned over to the Department's farm at Arlington for planting, in the same manner as previous lots, and are reported to have shown a good germination test.

From all over the country reports of injuries to the mulberry foliage by cold weather have been received. In most cases the foliage was starting well and was then cut off by frost. As a consequence many persons have lost their silkworms through lack of food, and this has had a serious effect upon the quantity and quality of the cocoons offered for sale to the Department, as will be shown later.

#### SALE OF REELED SILK.

During the year several ineffectual efforts were made to sell the raw silk which had been produced by the Department reels and which has been accumulating for some time. In June a bargain was made with Belding Brothers & Co., and the total amount on hand, 253 pounds, was sold at \$4 a pound, bringing a return of \$1,012. This amount was immediately deposited with the Treasury.

Department in compliance with the regulations. The price of raw silk has been steadily advancing for six months past, and by June of the present year ranged from \$3 to \$5 for Italian silks, Japanese silks, however, selling for something over \$6. The bulk of the product at the Department was Italian silk, the proportion of Japanese silk being very small. It is therefore thought that \$4 a pound represents a very fair value, considering that the reeling was done by American women of very short experience. All attempts to dispose of the waste products (frisons, pierced and double cocoons, and so on), have been ineffectual; there seems to be little demand for this material.

#### COCOONS PURCHASED.

American-raised cocoons have been purchased during the past year whenever offered, at rates of \$1.15, \$1.05, and 90 cents per dry pound for first, second, and third class cocoons. The Department has continued to assume the expense of transportation, providing for the purpose Government franks sent on application. While the standard of quality has been fully maintained, there has been a considerable falling off in the quantity of cocoons offered for sale, and it has amounted to hardly a third of that offered last year. This loss is to be attributed to some extent to the heavy spring frosts, which destroyed the mulberry foliage, and also to the fact that the eggs sent out a year ago were slightly below standard; but it was evidently due in part to a falling off in interest among producers for reasons already stated. Under ordinary conditions, the cocoons of the new crop begin to come in in straggling lots in May, and during the month of June they are usually being freely offered. During June of 1907, however, the end of the month showed the cocoons coming in but slowly, and the bulk of the buying ran over into the present fiscal year.

#### REELING OPERATIONS.

Reeling has been conducted as in previous years, only one of the two 4-basin Berthaud reels being operated. There is no available space for setting up the second machine, and no necessity for its use even if there were enough available cocoons to make its operation desirable. At the end of the last fiscal year 3 operators were actively employed in reeling. Their number was increased in July to 5, with the addition of an apprentice serving without pay. The 5 were employed until the end of December, when the reels were closed down for the year.

Four threads have been used exclusively, except in rare instances, when 5 and 6 were employed.

#### MISCELLANEOUS INVESTIGATIONS, THE EXHIBIT AT THE JAMESTOWN EXPOSITION, AND OTHER WORK.

As in previous years, several additional investigations have been entered into during the year, and some of the principal ones may be mentioned briefly here.

The investigations of the insects affecting stored products have practically been completed. A few questions of a nature not discussed in Farmers' Bulletin No. 45 are occasionally asked in corre-

spondence, necessitating continued investigations of a minor character.

A special agent in Florida has investigated some of the principal insect enemies of the pecan in that State, especially the budworms, which are credited as being the most destructive of the pecan insects in this country. Some elaborate work on the insects affecting acorns of the different species of oak has been begun looking toward a somewhat complete consideration of the subject. Investigation of insects injurious to shade trees has been continued, as in the previous year, and the increasing importance of some species, such as the imported willow curculio, will necessitate further observations with a view to discovering better methods of control than have hitherto been devised and employed. This insect is now very generally distributed throughout the Northern States, from Maine through New England, New York, Pennsylvania, and Ohio to Wisconsin, Minnesota, and North Dakota. It is a pest on poplar and willow, and is especially troublesome to nursery stock.

Much study has been given during the year to the important parasites of scale insects, and a technical bulletin has been published describing a number of forms new to science that either have been imported into the United States or have been sent here for study by the entomologists of foreign countries.

The exhibit of the Bureau of Entomology at the Jamestown Tercentennial Exposition occupied the time of one of the trained assistants of the Bureau for a portion of the year. It was arranged in sections so as to facilitate the location and study of any particular pest in the collection. The following subdivisions comprised the main part of the exhibit: Insects injurious to southern field crops; Insects injurious to fruits; Various insect pests; Parasites of domestic animals; and Household insects. A prominent place was given to the enlarged models of the malaria mosquito and the life history of the protozoan parasite carried by it. Large models of the yellow-fever mosquito and the salt-marsh mosquito were also exhibited, and the large models of the codling moth, the San Jose scale in all stages, the chinch bug, the Hessian fly, the house fly, and others attracted much attention from the visitors to the building.

The correspondence of the Bureau was increased over the previous year, necessitating a still further enlargement of the clerical force. The routine work in the insectary has also increased, and biological studies have been made of a large number of species not hitherto investigated. The work of determining the specimens for the entomologists of State experiment stations and other workers has also increased over the previous year. Many thousands of specimens have been received from these workers, and a considerable part of the time of a number of expert assistants was taken up in this way. This work is important and is a proper function of the Bureau, although it is barren of immediate practical results.

#### PROPOSED WORK FOR THE FISCAL YEAR 1908.

Work for the fiscal year is now well under way, and naturally, for the greater part, it consists of a continuation of the lines of investigation just indicated. Several new lines of work, however, have been added during the present fiscal year at the direction of

Congress. The first of these is an investigation of the insects injuring tobacco in the dark-tobacco sections of Tennessee and Kentucky, and some reference to this work has already been made in the body of this report. The second new investigation consists in a study of the depredations of the grape root-worm in the Erie grape belt of Pennsylvania with a view to carrying out demonstration work in its control. Provision was made to begin this work in the spring of 1907 on account of the necessity for an early start well before the beginning of the new fiscal year. Series of experiments and demonstrations are now in progress, including tests of sprays, timely cultivations, and the renovation of vineyards already seriously injured by the grape root-worm. Together with this work other important grape pests are being investigated, such as the grape berry moth, the grape leaf-hoppers, rose chafer, and others. This work is limited practically to the Erie grape belt and is carried out in connection with other investigations of deciduous fruit pests at the field station at North East, Pa.

Another new line of work consists in an investigation of the depredations of deciduous-fruit pests in California. The large fruit interests in that State and the recent attack of the pear thrips in the Santa Clara Valley led to a provision by Congress for the establishment of a field station in that State for this purpose, beginning with the fiscal year 1908. Two well-trained men, familiar with California conditions, have been assigned to the work, and attention will be at once given to the more important insect pests, such as the pear thrips, codling moth, California peach borer, grape Phylloxera, and others.

Attention was called in the last report to the desirability of establishing a field station on the Pacific coast for the investigation of insects injurious to grains. With the added funds appropriated by Congress this has become possible the present fiscal year, and an expert assistant has been placed in northern California to study all cereal and forage crop insects of the far West. Had this station been established during the last fiscal year, it would have been possible, by the transfer of parasites of the Hessian fly from the East, to bring about results of practical value, since the damage done by this insect in northern California during the summer of 1906 was severe.

Another new project taken up with the beginning of the fiscal year 1908, at the especial request of several of the horticultural commissioners of California and at the instance of Members of Congress representing the principal citrus districts, is the investigation of hydrocyanic-acid gas fumigation in southern California. The fumigation of citrus trees with this gas to control scale insects has been in California the standard means of control for years. The methods now followed are the outgrowth of these years of experience and give, as a rule, satisfactory results. There occurs, however, from time to time serious damage to trees and fruit. The use of this method has increased enormously with the betterment of the citrus market during the last few years, and it becomes of great importance to all citrus growers to have fumigation placed upon an exact basis to give it its greatest efficiency and to remove or greatly lessen the likelihood of any bad results. This investigation will be carried out during the fiscal year 1908 in southern California under the direct supervision of Mr. C. L. Marlatt, and will include a thorough survey of existing

conditions from the insect side, and also an examination of current practice throughout the district. In the fall and winter there will be conducted field tests of fumigation to discover the best formulas and methods from the standpoint of efficiency and the freedom from ill effects of trees and fruit. In this investigation the Bureau of Entomology will have the cooperation and assistance of the Bureaus of Chemistry and Plant Industry of the Department.

With the boll weevil, the reduction in the appropriation for the investigations by this Bureau prevents the work of this fiscal year from being conducted on as broad lines as was intended, but many of the important lines that have been under way and that have been suggested by recent investigations will be continued. The experimental field work now going on is located at seven points in Texas, one in Arkansas, two in Louisiana, and one in Indian Territory. Two hundred and thirty-eight acres will be utilized under contract, and the use of about as much more has been granted by private parties. The work is all being located in regions where the greatest damage may be expected. The general work of the investigation is divided into 26 distinct projects, to which different men are assigned and for which they become responsible. Among these projects are a further study of the flight of the boll weevil and its bearing on control and quarantines; life-history studies in the Red River Valley in Louisiana sufficiently comprehensive to reveal points which will necessitate changes in the system of control perfected in Texas; the exhaustive investigation of insecticide control in the light of discoveries recently made; a study of the possibility of attracting the weevils in the fall or in the spring by food supply and shelter; a study of the climatic control of the weevil with reference to probable future damage; an investigation of cultural practices in relation to control of the weevil; a continuation of experiments and observations on the most favorable time for fall destruction of plants, and the relative effectiveness of this operation at different times; study of new types of machinery designed for weevil control, and other lines of equal or lesser promise. Special efforts will be made in the practical utilization of the information that has been obtained regarding parasites and predaceous enemies of the weevil. Shipments of parasites will be sent from Texas to the infested region in Louisiana. In cooperation with the Louisiana crop pest commission, an agent has been stationed at Shreveport, La., to assist in this work. A series of special experiments will be carried out in Texas in inducing parasites of related weevils to attack the boll weevil. Cooperative work is under way, in connection with the Mexican authorities, having a bearing upon the study of the parasites, and Mexican parasites will be sent to the United States in a much more systematic way than has been possible in the past.

The work against the gipsy moth is at this time of writing well under way, and consists in the continuation of the methods adopted for the previous fiscal year. Following the spraying work, the cleaning up of roadsides will continue, and as the winter approaches scouting and the destruction of egg clusters will follow.

With regard to parasites, arrangements have been made so that European material will continue to be received practically through-

out the year. With the conclusion of the gipsy-moth caterpillar season in Europe, brown-tail moth eggs will be received; the predatory Calosomas will continue to come up to autumn; gipsy-moth eggs will be received during the autumn; and brown-tail moth nests during the winter. With the opening of the season will begin shipments of larvæ of both brown-tail and gipsy moths. A further effort will be made to introduce the Japanese parasites by correspondence, and, if necessary, with the cooperation of the Massachusetts State authorities, an agent will be sent to Japan for this purpose. The parasite laboratory at North Saugus, under the control of the Massachusetts State authorities, will be changed in location and much enlarged, in order to accommodate more workers and in order to handle the greatly increased amount of parasitic material coming from Europe under the joint auspices of the Bureau of Entomology and the Massachusetts officers.

The work in regard to forest insects has been carried on almost entirely in the direction of projects already begun, and the same may be said for the work on grain insects, with the exception of the new Pacific Coast station referred to above. An investigation of alfalfa insects will be included.

With regard to the white fly, the investigations of the past year have laid a good foundation for an exhaustive study of the whole problem with a satisfactory outlook. The general work of the present fiscal year will follow the lines already indicated, but the increased funds provided by Congress will make it possible to conduct the experimental field work on a much larger scale and thus secure practical results of much greater value. Measurably conclusive results from experimentation with means of control, both by spraying and gassing, should be reached within a reasonable length of time, and possibly by the end of the next year's work. The work with fungous diseases will take more time, in all probability, and the introduction of parasites will also require additional time. The absence of parasites and important natural means of control other than fungous diseases in the white-fly districts of the Gulf region warrants the expending of considerable effort to promote the introduction of parasites, particularly as the horticultural conditions of Florida are such that concerted action with the usual remedies will be very difficult.

In bee culture bee diseases will continue to be the subject of most importance for investigation. The bacteriological work which has been begun so favorably will be continued, and detailed studies will be made of the various micro-organisms found. Inoculation work will be continued on a large scale, and an attempt will be made to determine the cause of European foul brood. All of these investigations will point toward improved methods of treatment. A bulletin on the practical control and inspection of bee diseases will be presented during the year. Investigations looking toward the discovery of the cause of swarming and leading to work on swarming control will be undertaken, and experimental work upon queen mating will also be undertaken.

The other work of the Bureau will consist in carrying on the investigations already begun.

**SUGGESTIONS AS TO WORK RECOMMENDED FOR THE FISCAL YEAR  
ENDING JUNE 30, 1909, FOR USE IN PREPARING ESTIMATES.**

As the work upon the various projects entered into continues, opportunities are seen in many instances where more assistants can be used to advantage in the hastening of important results, and with the employment of further assistants comes the necessity for larger funds for expenses. It therefore seems most desirable that the fund for general entomological investigations be increased from \$113,800 to \$150,000. This will enable additional men to be employed and will extend these important investigations in a way to insure greater efficiency, and thus, naturally, increase the speed in the accomplishment of practical results. Should this additional appropriation be made, the increased amount will be divided among the different lines of work in the directions in which such increase is seen to be most needed.

With regard to the boll-weevil investigations, it is not considered by the Bureau that the problem is by any means completely solved. It is believed that more effective means of control than those now known may be discovered. In regions that are now being invaded or almost to be invaded there is urgent need for methods to meet the new conditions. The pest has caused the actual abandonment of land in some parts of Texas, and where this has occurred the conditions approach those in regions now being invaded. The work already done along some lines, notably with parasites and predatory enemies, has just reached the stage where most important results may be expected. This work, in the nature of the case, must go slowly, but it should be prosecuted until every possibility has been exhausted. Isolated colonies ahead of the territory that will be reached naturally in several years are increasingly likely to be found, and the immediate eradication of one of these would mean a saving of many thousands of dollars to the locality concerned. For the reasons given above, it is considered that the situation urgently demands a continuance of the present appropriation of \$40,000, and that it would be wise to provide an additional amount of at least \$10,000 to be used in case isolated advance colonies should come to light.

In the work of preventing the spread of the gipsy moth and the brown-tail moth, the results obtained have been so excellent as to show thoroughly the practical value of this appropriation by the General Government. The spread could be still more effectively checked and the infested area be more rapidly reduced in direct proportion to the expenditure of more money. It is the urgent desire of the inhabitants of the infested region that more work should be done by the Government. In view of results, this desire seems reasonable, and an increase of \$100,000 is therefore recommended in the sum to be devoted to preventing spread of moths—\$250,000 instead of \$150,000.

In regard to salaries, I respectfully urge that two additional clerks of Class 3 be added to the statutory list. Prior to 1905 one such position was contained in the list, but was dropped that year. The object of this recommendation is to establish on this roll a proper opportunity for promotion which does not exist at present. Owing to the increased activities of the Bureau a larger clerical force is needed, and the lower positions made vacant by promotions

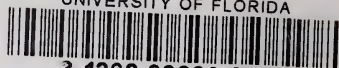
could be filled with new employees. There are on the roll at present two skilled stenographers of long service and of the most deserving character who should have been promoted to the third class before this. The addition of these two clerks will therefore allow a sufficient increase in the clerical force and at the same time permit the deserved promotions. I further recommend that the salary of the chief clerk of the Bureau be raised from \$1,800 to \$2,000 per annum. This will place the salary of this employee more nearly on a par with the corresponding positions in other Bureaus, and the promotion is thoroughly deserved. I also respectfully urge that the salary of the Chief of Bureau be increased to \$5,000. The importance and scope of the work conducted in the Bureau are such as to warrant this increase.

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